INSTRUCTIONS FOR THE OPERATION, CARE, AND REPAIR OF GENERATING SETS, MOTORS AND MOTOR CONTROL PANELS

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OF

GENERATING SETS, MOTORS

AND

MOTOR CONTROL PANELS

(Reprint of Chapter 24 of the Manual of Engineering Instructions)

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CHAPTER 24.

GENERATING SETS, MOTORS, AND MOTOR CONTROL PANELS.

SECTION I.—GENERATORS AND MOTORS.

PART 1.—OPERATION.

Pamphlets and plans.

24–1. The instructions contained in this chapter are general enough to cover all types of electrical machines. In the case of the more important auxiliary units, specific instructions covering operation and assembly are issued in the form of pamphlets by the manufacturers, and these should be made readily available to the personnel who operate, care for, and repair them. The bureau arranges for sufficient lithoprints or blue prints to supply each ship with a general arrangement plan, and sufficient detailed plans to enable the ship's force to handle most of the ordinary repairs likely to come up in operating the various electrical units. These plans should be carefully indexed, kept up to date, and should always be referred to when machines require overhaul or repair, or when ordering new parts by requisition.

Inspection after assembly, before starting.

24–2. (1) (a) After assembling a machine, a final inspection shall be made to guard against starting with loose bolts, improper clearance, short circuits, broken insulation, or any damaged parts.

(b) The binding wires shall be examined all the way around, especially those on high-speed armatures.

(c) The air gaps should be equal, as measured under poles of the same type, and poles should be uniformly spaced between tips.

(d) The armature clips on both ends are easily bent out of shape when handling and it is essential that these leads be straightened and uniformly spaced before starting.

(e) The use of two sets of series field connection strips, one connected to each polarity of the machine, usually without the

interposition of circuit breakers, necessitates extreme care in guarding against short circuits. In case of a short circuit between these strips or coils the machine would build up as a series generator with absolutely no protection other than a burn out or shutting down. These parts are carefully designed for ample clearance, and suitable spacing blocks are provided to maintain these clearances; but there is always a possibility of strips or leads being bent out of shape while handling, and a very careful inspection is therefore necessary before starting.

(f) Commutators are frequently fitted with radiating vanes, for cooling, and these vanes should be examined to see that they are properly separated and that the stationary vane guard is assembled with the proper clearance.

(g) Slotted commutators should have the slots cleaned out as an insurance against bridging between segments.

(h) Brushes should be adjusted to an equal tension of 1½ to 2 pounds per square inch each on the commutator brushes and about 4 pounds per square inch each on collector ring brushes. The brush holder studs should be checked for their alignment with the armature shaft and to see that they are rigidly secured to the rocker. The holders in turn should be securely clamped to the studs. The brushes should fit in the holders snugly, but not so snugly as to bind. Check each pigtail to make sure it is not loose. Such looseness is a frequent cause of abnormal brush heating.

(i) Inspect the lubricating oil system, and see that sufficient oil of the right quality has been supplied.

Inspection after assembly, after starting.

(2) (a) On starting up, the speed of the machine shall be carefully determined to see that proper speed is maintained. No chattering or undue vibration should exist as the load is thrown on or off.

(b) The commutator or collector rings should run true and smoothly without chattering of the brushes, and all sparking should be eliminated.

(c) If a lubricating oil cooling system is provided, the temperature of the inlet and outlet oil should be taken until the running heat is established, and if the temperatures are excessive the trouble shall be traced out and remedied before extended running is undertaken. Samples of the oil should be frequently taken, and these should be examined for metal dust from defective bearings and for the presence of dirt in the system. Oil should be renovated until the system runs clean. Examine the automatic oilers and the oil rings and make sure that all are functioning properly.

(d) When the set is in operation make frequent inspections to see that the oil cooler is getting circulating water, and examine the oil to detect any water resulting from leakage in the cooler.

Starting a generating set.

24–3. The steps in starting a generating set are as follows:

(a) Examine both steam and electrical ends to see that all rotating parts are clear. Turn the armatures of small generators one complete revolution by hand.

(b) See that the commutator brush rigging and brushes are clear, and that the brushes react to spring tension.

(c) See that all switches are open and that the rheostat handle is so set that all field resistance is cut in.

(d) Start steam end. (See instructions for driving units, ch. 30.)

(e) Bring the machine up to its rated speed and see that voltage is normal with the rheostat in low-voltage position. (For procedure if voltage fails to build up, see art. 24–5).

(f) Build up voltage until it is three or four volts higher than the bus voltage.

(g) Throw in circuit breaker.

(h) Throw in equalizer switch.

(i) Throw in negative switch.

(j) Throw in positive switch.

(k) Regulate voltage to divide the load properly. (Indicated by the voltmeters of the two or more machines in operation).

Cutting out a generating set.

24–4. The steps in securing a generating set are as follows

(a) Take most of the load off the machine to be secured, by field rheostat.

(b) Trip circuit breaker.

(c) Open positive and negative switches.

(d) Open equalizer.

(e) Put rheostat in position where all resistance is cut in.

(f) Secure steam end. (See instructions for driving units, ch. 30.)

(g) Blow out armature coils, commutator spider, and air gaps, etc., with compressed air. (See art. 24–26.)

Procedure if voltage fails to build up.

24–5. (1) In case a machine gives the opposite polarity to that desired when building up its voltage, separately excite the fields with the correct polarity to reverse the residual magnetism. This is done in the following manner: First, disconnect the brush leads at the headboard; second, on the machine panel throw in—

(a) Shunt field switches, if used.

(b) Circuit breakers.

(c) Common negative switch.

(d) Positive light or power switch.

Momentary excitation is sufficient, so that a moment after closing the positive, the circuit breakers should be tripped, other switches pulled, and the machine again made ready for normal operation. Failure to build up voltage is sometimes due to an open point in the shunt field circuit and sometimes to reversal of the shunt field connection with respect to the armature. A reversed field connection can usually be detected by the residual voltage tending to approach zero when the field switch is closed, and this indicates that the diagram of connection drawing has not been properly followed in the wiring.

(2) If found properly connected, it should be assumed that the polarity is actually reversed. Shut down the machine and separately excite the fields with the correct polarity to reverse the residual magnetism as described above, obtaining excitation from another machine. The resultant polarity must be checked after every separate excitation.

Constant voltage.

24–6. In operating a generator, keep the voltage constant and the load equalized by the field rheostat. If the voltage is such that an excessively low or high position of the field rheostat is required, the speed of the generator shall be checked.

Checking readings. 24–7. Oil gauge readings and bearing temperatures shall be frequently checked. The oil should be changed, and filtered or renewed periodically, and each time the fact shall be entered in the log. If an oil-cooling system is installed, constant vigilance is necessary to detect promptly corrosive punctures or leaks in the cooling coils, which allow the passage of salt water into the oil. (See ch. 10.)

Running at overload. 24–8. Navy standard generators are designed for 25 per cent overload for two hours. However, this extra capacity should always be considered as a safety factor and machines shall never be habitually run at a greater than rated load. When necessary to operate generators at greater than rated load, inspect all parts such as bearings, field coils, and brush rigging every five minutes for overheating.

Parallel operation. 24–9. Any difficulty met in obtaining satisfactory parallel operation is usually due either to differences in compounding or inequality in the resistance of the series field circuits from the equalizers through series fields and cables to the bus. A slight unbalance in the resistance of the two circuits would result in an unequal current flow, so that the machine with the lower resistance series field would carry a greater share of increase in load to the extreme of throwing out the other machine entirely. A simple resistance determination will disclose this trouble, and the remedy consists in shunting part of the flow in the heavier field. Sluggish or erratic governor operation is often a cause of the difficulty, and the remedy lies in a careful disassembly, cleaning, and overhaul of the governor. (See ch. 30.)

Mechanical balance. 24–10. Any appreciable vibration should be located and corrected as soon as it occurs. All rotating parts are carefully balanced at the factory, and an investigation of balance trouble should therefore consist of a careful search for misalignment, sprung shafting, or something chafing the rotating element, before shifting any balancing weights. Brushes sticking in the holders have been known to upset the balance. Balancing pockets in the armature flanges, in which lead can be peened, are provided for correcting any unbalancing of the armature.

Effect of brush position. 24–11. After running a short time, the appearance of the brush faces will indicate whether the brushes will soon wear to a proper fit over the entire surface or not. Any of the brushes showing a fit over only a very small area should be sandpapered again. It will be found that reliable results in compounding tests can not be obtained before the brushes are all thoroughly fitted. Shifting the brushes around the periphery of the commutator has an effect on both the compounding and commutation. In a generator, the armature current reduces or increases the main field magnetization, depending on whether the brushes are ahead of (shifted in the direction of rotation) or behind the true neutral point, thus having considerable influence on the compounding. In order to prevent sparking, the brushes must be held in such a position that the armature coils short-circuited by the brushes are under the influence of the commutating poles, but occasionally shifting from an exact center to produce slight changes in compounding is permissible. Even the most careful setting with the tram is subject to slight errors, and as a final adjustment, when working to very

close limits, slight changes in brush position may be necessary. On a machine that is running, care must be exercised, when shifting brushes, to guard against raising the yoke out of its support, which would pull the lower brush holders into the commutator and cause serious damage. In spite of these instructions, however, machines should habitually be operated with the brushes set at the neutral point at which the machine was initially compounded and adjusted. The necessity for a departure from the manufacturer's punch marks is a trouble indicator.

Sparking.

24–12. Sparking may occur at the brushes for any one of a number of reasons which are itemized and for which remedies are discussed under article 24–31. As soon as sparking occurs the conditions which cause it should be rectified, as these conditions will rapidly become aggravated.

Switchboard manipulation.

24–13. The same method of operating switches at the switchboard should be employed by all members of the dynamo-room force.

PART 2.—CARE.

Cleanliness.

24–20. (1) Keep both the interior and exterior of a generator or motor free from water, salt, lint, dust, dirt, and particularly oil. Do not allow oil to enter the machine with the cooling air and thus be deposited on the windings. An excessive accumulation of dirt may eventually ground the coils and burn them out. Dirt, aside from restricting the air flow, is a heat insulator.

(2) Particular care should be taken to guard against carbon dust from brushes and copper dust from sanded commutators.

(3) When cleaning a machine care must be exercised not to crowd dirt into narrow spaces between conducting parts, or in the air ducts.

(4) Care must be taken in filling oil containers on ring oiling motor bearings that the oil level is not so high as to result in leakage along the motor shaft. Filling these bearing oil containers too full causes overflow into brush rigging and lower field coils and creeping of oil into interior of spider and thence to commutator and windings.

Dirt and dust in coils.

24–21. Should dust or dirt be lodged with oil on the coils, remove it by means of a cloth dampened with carbon tetrachloride (Pyrene liquid), taking care not to touch the steel parts, as corrosion will develop due to a combination of moisture and carbon tetrachloride with the steel. Remove all salt deposits from the machine. Clean rags, or preferably cheesecloth, shall be used in all windings. The use of any material which deposits lint must be avoided.

Painting.

24–22. The use of paint on the insides of field frames and housings eventually results in paint getting on field coils, leads, and brush riggings. As ordinary paints usually contain materials of a conducting nature, such as white lead, they must not be used in the vicinity of windings or any live parts. This precaution applies particularly to open motors, brush rigging, and electrical panels. On the above-mentioned parts the best grade of insulating varnish shall be used. All fiber insulating distance pieces and bushings should be carefully cleaned and scraped and coated with insulating varnish. Electrical leads should be properly served, and should always be painted with insulating varnish.

Tightening bolts. 24–23. All bolts shall be gone over occasionally to keep them tight, particular attention being given to the bolts used to clamp any insulation. Fiber insulation, used around brush holder brackets and collector rings, and wooden spacing blocks are sometimes used in supporting connection strips, and as this material is subject to considerable shrinkage, the bolts must be tightened frequently until the insulation is thoroughly seasoned. In setting up on brush stud nuts always check the stud alignment, as any throw of the end brushes ahead or back of their normal position will cause sparking in various degrees. Unless a commutator shows evidence of loose bars the commutator clamping bolts should not be disturbed. Serious distortion of the clamping rings and segments is sometimes caused by excessive tightening of the commutator clamping bolts, so considerable care must be exercised in adjusting them.

Commutators, collectors, and brushes. 24–24. Most of the sparking experienced after a machine is in operation is due to mechanical defects, such as rough or eccentric commutators, or brushes not riding properly. If the commutator and rings are sufficiently true and smooth, the brushes will feel "dead" when the machine is at normal speed. The brushes should be staggered to cause the commutator to wear evenly. If this is not done, the commutator will wear into shoulders and ridges which will finally necessitate turning down. When fitting new brushes, care should be taken that the brush fits its holder loosely enough to permit up and down motion, but not so loosely as to cause excessive wobbling. Commutator slots must be cleaned out occasionally to keep all the mica well below the wearing surface, special care being taken to eliminate all projecting fins or slivers. The use of oil on commutators is unnecessary except in rare instances where some of the older types of hard carbon brushes are used. With most of the modern brushes of a graphitic nature, oil is actually detrimental to commutation. Besides the effect on commutation, oil, vaseline, or other commutator lubricant should be avoided on commutators, as such lubricants have a tendency to work into the side mica, causing insulation breakdown and short circuits between segments. Commutators are slotted in order to use the modern graphite brushes, which have very desirable current-carrying and lubricating characteristics, but which will not wear mica down evenly with the copper. In general, therefore, it never is advisable to lubricate slotted commutators. The collector rings of machines using brushes of a metallic composition run at higher pressures than commutator brushes give, and best results are obtained on collector rings if a slight amount of oil is applied occasionally with a small brush or canvas swab. Just enough oil should be applied slightly to lubricate the brushes and produce a polish on the rings. Brush holder lever arms shall be inspected occasionally to see that the springs give uniform tension, and the brushes should be moved up and down to insure that they work freely in the boxes. An accumulation of dust has been known to settle in the clearance space around brushes and embed the brushes so tightly in the boxes as to prevent their removal without breaking. Brush holders are so made that the spring tension can be easily adjusted to keep the brush pressure uniform. As mentioned in article 24–2 (1) (h), the springs on the commutator brush holders

should be adjusted to give 1½ pounds per square inch each, and on collector rings approximately 4 pounds. Uniform brush pressure is a very important factor in maintaining successful collection of current from the commutator and collector rings.

Use of gasoline.

24–25. Generally speaking, the use of gasoline should be avoided when working with electrical machines. If it is ever used, the limitations and instructions contained in chapter 38, with special regard to articles 38–149 and 38–150, should always be kept in mind.

Cleaning windings.

24–26. A compressed-air jet, or even a hand bellows, is a most effective means of cleaning the windings of rotor or stator and for dislodging the metallic dust which accumulates between the commutator segments. A vacuum cleaner is even more effective, but except on some of the latest ships is not usually available. Frequent use of such a device will save much expensive overhaul. Before using the air jet, the freedom of the air from water must be assured, and care must be taken to avoid the danger of driving grit into bearings.

End windings.

24–27. Once a year clean the end windings thoroughly and apply a coat of air-drying insulating varnish. This varnish may be sprayed on by using compressed air in connection with an atomizer. In varnishing windings care should be taken that no varnish is blown into electrical contact surfaces where it will tend to insulate them and prevent current from flowing. During the varnishing operations all brushes should be removed and the commutator should be wrapped with canvas.

Air ducts.

24–28. Keep the air ducts free from dirt; any restriction will seriously interfere with the flow of the cooling air and cause excessive heating.

Prevention of moisture when shut down.

24–29. If an electrical machine is to be shut down for any period exceeding 24 hours, and it is provided with heating coils, the dampers at the air inlet and outlet ducts should be closed and steam turned into the coils. This will heat the interior of the machine several degrees above the room temperature, and so prevent the accumulation of moisture on the windings and the working parts. Where electrical heaters are provided they should be used in preference to steam coils. Their use is especially necessary on large idle motors or generators during long periods of damp weather. Care must be taken with any drying-out heaters that the heat is evenly diffused and that local spot heating does not result. Many machines, due to peculiarities of location, are liable to an excessive moisture precipitation. In such cases, the use of an ordinary portable 40 to 60 watt lamp placed well within the frame and the whole covered with a tarpaulin is recommended to produce the necessary temperature rise where special heating facilities are not provided. Free circulation of the air through the windings should be assured unless these precautions are taken.

Causes of overheated bearings.

24–30. (1) Overheated bearings may result from a number of different causes, among which the following are most frequently found:

(a) Bearings out of alignment.
(b) Insufficient oil.
(c) Poor-grade oil.

(d) Dirt or grit in oil.
(e) Gummed-up oil leads.
(f) Poorly fitted bearings.
(g) Bearings too tightly set up.
(h) Scratched or corroded journals.
(i) Overload.
(j) Conduction from overheated electrical parts.

(2) Dirt may cause the gauge glass to indicate oil when none is present, and a clogged top vent will cause the same effect; oil rings will wear out of round and fail to rotate; lack of end play will cause binding or heating, the trouble becoming aggravated as the shaft expands; a bent shaft will cause vibration and grinding at the journals. All these troubles should be guarded against by frequent, intelligent inspection. Until a machine is available for overhaul, overheating may often be checked by the use of a liberal supply of fresh, cool oil, or in emergency by the use of water, taking care to keep the electrical parts clear of either oil or water.

(3) Inspection will usually disclose the particular trouble, and the remedies are obvious.

Sparking and its remedies.

24–31. (1) Sparking at the brushes indicates a condition which should be promptly remedied to prevent serious trouble. It may be caused by any one of a number of conditions, or their combinations, and oftentimes the character of the sparking will indicate the underlying trouble. The following table, with references to subsequent subarticles, is offered as a tentative guide in trouble finding, though it should not be accepted as final:

(a) Incandescence of the carbons (4).
(b) High, white spark under one brush (6).
(c) Periodic sparking (7).
(d) Blue, snappy sparks (9).
(e) Ring of fire (9, 5).
(f) Continuous heavy sparking (4, 9, 10).
(g) Sparking varying with resistance (11).
(h) Continuous light sparking (2, 3, 8).
(i) Sparking on starting up (11).
(j) Sparking at heel or toe of brushes (2).

Off neutral.

(2) *Brush rocker ring at the wrong place.* Set the rocker ring to the square mark on the frame.

Brush spacing.

(3) *Brushes wrongly spaced.* This may be caused by a blow either to the brush holder or to the rocker ring, bending either out of true, or may be due to a poor setting in tightening of the brush-holder stud. A convenient method to test spacing is to cut a strip of paper until it fits around the periphery of the commutator, then fold it in divisions corresponding to the number of rows of brushes. Place this template around the commutator, and check the brush edges against the creases.

Brush contact.

(4) *Poor brush contact.* This may be due to high spots on the brushes, to the binding of the brushes in their holders, or simply to varying spring tension among the different brushes. With any of these defects the result is to reduce the effective brush area, forcing the actual effective area to carry excessive current. This will induce heavy sparking and often heat the overloaded carbons to incandescence. In the first case, place a piece of sandpaper face up on the commutator, and by revolving the commutator with the

brushes held in firm contact, grind the faces down to an even bearing surface. In the second, clean the holder, and clear the sides of the carbon of fins and ledges. In the third, even up the spring tension all around, bearing in mind that the brushes underneath should be set up slightly tighter than those on top to balance the action of gravity.

Cleaning commutator.

(5) (a) *Commutator dirty or rough.* The commutator should be kept clean by wiping with light canvas, cheesecloth, or woolen cloth, care being taken not to allow any threads to lodge on the brushes or between the segments. If carbon dust and oil collect on the commutator, they will give trouble. Once a dull, glazed, brown-black finish has been obtained on the commutator, very little further roughening will occur. It should be the ultimate aim of the operator to develop this clean smooth chocolate color on commutator bars. Sandpaper should be used very lightly on the commutator, if at all, and emery cloth shall never be used, as emery is a metallic conductor which, if lodged between segments, will short-circuit them. If it does become necessary to use sandpaper to smooth the commutator, the sandpaper should be fitted in a wooden block which has been shaped to the proper curvature, and should be held firmly against the surface and drawn in the direction of rotation of the armature. Projecting mica insulation will not yield to the action of sandpaper, and must be turned down with a light cut in a lathe, or by a commutator grinder, a finish being given with fine sandpaper.

Grinding a commutator.

(b) Grinding at or near full speed is the best method of truing or smoothing a commutator or collector, and if facilities are available for grinding, this method is always preferable to using a lathe cutting tool. In grinding, a large number of very light passes must be taken to insure a true cylindrical surface. Any undue haste or crowding of the grinding wheel will result not only in a rough surface, but often in a noncylindrical shape. During the grinding operation all windings should be protected from the deposit of copper dust, the field coils being protected by a stationary guard and the armature fitted with a canvas head securely bound on the commutator and armature surfaces. The ventilating spaces under the commutator may be protected by stuffing them full of waste, care being taken to remove this waste when through grinding. After grinding, the machine should be thoroughly cleaned and the commutator slots gone over with a sharp tool to remove any copper dust or bridges, and to smooth up the edges of the segments.

Metal in brushes.

(6) *Copper embedded in the brush.* A bright sparking appearing under one brush and gradually cutting a groove in the commutator is due to a particle of copper which has become embedded in the brush. This reduces the local contact resistance, causing an abnormal current to pass at this point, which is shown by the spark. Remove the copper by scraping the brush face with a knife and sandpaper the brush to a fit.

Commutator out of true.

(7) *Commutator bars, loose, high, or low.* A single bar in the commutator which is out of the cylindrical surface will cause the brush to vibrate, producing poor contact and consequent sparking. As soon as possible, the machine should be stopped, and the bar should be tapped back into place with a block of wood and a mallet. A low bar is seldom found. It usually indicates a slacking up of

the commutator and bolts, and an entire readjustment of the bars. If the commutator bars are loose, the nuts on the end should be tightened up, and the whole commutator be given a light cut.

High mica. (8) *High mica.* Sometimes the mica between the segments is of such a hard quality that it will not wear down so rapidly as the copper, the effect being that of a series of high bars—vibration of the brushes and consequent sparking. As stated under subparagraph (5), the only remedy for this condition is grinding or using the turning tool, as sandpaper will not cut the mica. A large percentage of commutator troubles may be eliminated by "undercutting" the mica insulation. The process is easily performed by a good and careful mechanic, and accomplishing it is the only positive way of eliminating "high mica" troubles. In merely cleaning out the slots of a properly undercut commutator a thin wooden wedge should be used in preference to a sharp steel instrument. In cutting out high mica insulation a steel cutting tool will of course be necessary.

Defective coils. (9) *Defective coils.* These fall into three classes which are discussed under (a), (b), and (c).

Open-circuited coils. (a) *Open-circuited coils.* The trouble is usually found to be a loose connection between the armature coil and the commutator bar. The condition is indicated by a blue, snappy spark, just as the bar leading to the defective coil passes under a brush. If the contact is definitely broken, the spark will hold between the bars, producing a ring of fire around the commutator and burning the mica between the segments. The connection may at times be broken, and at other times give sufficient contact to carry the current without trouble. This will give rise to intermittent sparking. A case is on record where excessive sparking was caused by a fracture of the laminated copper risers connecting the commutator bars with the coil terminals. This fracture was not apparent on visual examination, and was only found after a Wheatstone bridge resistance determination had traced down the bad point. To locate accurately an open-circuited coil, if inspection does not disclose it, remove all brushes from the commutator except one pair. Connect across these brushes leads from the lighting circuit, with a lamp in series, or use two dry cells to furnish a low voltage supply. With a low reading voltmeter, take readings from bar to bar around the commutator, rotating the commutator slowly so that the bars will be successively under the brushes. If readings are the same all around, no trouble is indicated. If the reading across one coil is equal to the voltage across the brushes and all the other readings are low and of equal value, the open circuit is found. An aggravated condition will often be indicated by local high temperature, and sometimes by an actual burning of the commutator bar attached to the defective coil.

Short-circuited coils. (b) *Short-circuited coils.* A rough test for this condition consists in holding a piece of iron (screw driver or other tool) a few inches from the end windings. The iron will throb each time the short-circuited coil passes. To locate the defective coil accurately, test as described in the preceding paragraph, using the low voltage method. In this case a zero reading or a reading materially less than the other equal readings will indicate the trouble. This

condition is also accompanied by local high temperature and often by burning of the commutator segment.

Grounded coils.

(c) *Grounded coils.* The existence of this condition may be determined by reading the armature resistance to ground with a megger. At least one-half megohm is required for proper operating condition and the initial insulation resistance to ground is 1 megohm. If a ground is indicated by this general test, use the low voltage test as described under (a) above, by connecting one voltmeter lead to the shaft and the other to each segment in turn. If the readings are the same (practically zero), the armature is not grounded. If grounded, the readings will vary, and there will be two segments with practically zero readings. One of these is the real and the other a phantom ground. Mark both with chalk, rotate the armature a few degrees, and again make the test. The real ground will read on the same bar as before, while the phantom will shift to another bar.

Eliminating moisture grounds.

(d) Baking will often remove grounds, and a jury oven may readily be rigged by using a box or even a tarpaulin for the oven; anything big enough to cover the armature, or even the whole machine. By using a lamp bank, maintain a temperature of from 135 to 150° Fahrenheit, and take megger readings to ground until the insulation resistance reads one-half megohm or better. This may take several days. If the field coils have moisture grounds, the armature may be disconnected and a properly regulated current applied to the field windings for drying out. A thermometer should be placed in the windings to ascertain the rise in temperature, which, by properly adjusting the current, should be at a slow and uniform rate.

(e) If the trouble can not be readily remedied, the armature should be replaced by a spare, and the old armature should be repaired promptly.

Temporary coil repair.

(f) In emergency or lack of a spare, temporary repair may be effected by disconnecting the broken coil from its segments and insulating the loose ends. The disconnected segments should then be connected by bridging them with a piece of strip copper of sufficient size to carry the current, soldering, if practicable, to secure a good connection at the segments.

Overload.

(10) *Overloading.* An overloaded machine will spark heavily. If sparking starts suddenly without apparent reason, the controlling ammeter should be read first of all. While all naval machines are designed with an overload factor, they should never be run in this condition except temporarily and with good reason. Temperature rises under overload are over the design limits and will soon break down the insulation. When an inclosed motor is found running hot, it may be opened to cool it down, but care should be taken to see that it is not left open where dust and moisture may be collected. If overheating occurs too often, the motor is either overloaded or something is wrong, and the trouble should be searched out and corrected. Checking ampere load and speed after each overhaul can not be overemphasized. This practice greatly assists in locating trouble and familiarizes the men in the use of instruments and acquaints them with normal conditions.

Dirt between bars.

(11) *Starting up.* Sparking is sometimes observed when starting up a machine which has not been properly cared for, the sparking often taking the form of a ring of fire around the commutator. Dirt, which has collected between the segments, is usually the cause, with the dirt forming crosses which are burned out as the voltage increases. This always indicates a poorly cared for machine, and the condition should not be tolerated, as insulation will eventually be burned out.

Weak field.

(12) *Weak field.* A weak field will ordinarily cause a machine to spark. It may be caused by loose field contacts or by burned-out coils in the field. A variable contact in the field will cause sparking, as resistance is increased.

The yoke.

24–32. If for any reason a brush yoke is to be removed, the yoke, the casting to which it fits, and all connections should be plainly marked, so that they may be readily replaced in their original positions. The proper position of the yoke is determined when the generator or motor is tested at the factory and should be plainly marked. However, as these marks correspond to the full-load position, and as the motor or generator may run at less than full load, it may be necessary to shift the position of the brushes slightly to secure the best commutation. This latter statement does not apply to interpole machines, the brushes of which do not require shifting for various loads, the neutral position for the brushes being marked.

Handling an armature.

24–33. The greatest care shall be exercised when handling an armature. Wrap armature and commutator with canvas before handling. It must not be allowed to bump while being lifted. Before lowering it on deck, always provide a pad or thickly folded tarpaulin for it to rest on. It is always preferable to rest the shaft ends on blocks or trestles, but in using such blocks, avoid taking any weight on the windings or commutator. In rigging slings, pass them near the shaft ends and use a spreader to prevent sliding into the commutator or windings. While the armature is clear of the frame do not allow small pieces of iron, such as bolts or filings, to attach themselves to the pole pieces. Carefully examine both armature and frame before replacement to be sure that both are free of foreign matter.

Setting the armature for concentricity.

24–34. The frame should be concentric with the armature after the machine has been assembled. To test for concentricity the air gap should be measured in the following manner: Examine the bearings first and see that the clearances are not excessive. Excessive drop should be remedied before proceeding. Use a tapered stick about 5 inches long, three-eighths of an inch wide, and a quarter of an inch thick at one end, tapered down to one-sixteenth of an inch at the other. Graduate one of the tapered faces at each one-half inch along its length. Now number the poles for reference and take a reading between each pole (main) and armature at front and rear of the machine. Rotate the armature one-quarter of a turn, and take another series of readings, and repeat this until four sets of readings are obtained. Divide the sum of the readings under each pole by 4, and compare the results, determining thus the direction in which the frame must move to equalize the readings. Now release the frame holding-down bolts, jack it up by the elevating screws usually supplied for the purpose, and insert or

withdraw liners under the feet as necessary to give the proper direction of movement. With the liners set, back off the elevating screws, set up loosely all around the holding-down bolts, tighten them equally, then set them up very tight. Recheck the gaps and, if necessary, repeat the operation. After such an adjustment, remember to readjust all brush tensions.

To remove a pole.

24–35. To remove a pole, it is not necessary to remove the armature. First disconnect the field windings, and then remove the bolts which secure the pole to the frame. Slide the pole out with its winding. In replacing, be sure to put back under the pole the same number of liners or shims of high permeability sheet iron only as were found there upon removal. After setting up, check the air-gap measurements as described in article 24–34. When a spare pole has been installed, it may be necessary to add or remove liners in order to rectify the air gap.

Section II.—Control Panels.

Part 1.—Operation.

Starting a motor.

24–40. In starting up a motor the procedure is as follows:

(1) Panel type:

(a) See that the starting arm is in the off position, and that all field resistance is out.

(b) Close the line switch, or circuit breakers.

(c) Move the starting arm to the first contact button, and then by successive quick movements and pauses, raise it to the full current condition, where it should be held by the no-voltage solenoid. Thirty seconds should be taken for this operation if practicable.

(d) If the machine is variable speed, move the field resistance lever until the required speed is obtained.

(2) Controller, drum type: Move the controller arm slowly from point to point of its travel, allowing the motor to come gradually up to its running speed. A distinct pause at each star wheel release point must not be omitted.

(3) Contactor panel, automatic type: Close the line switch, or circuit breakers. The machine should work up to its rated speed without further attention through the operation of its relays.

(4) Controller, drum type with automatic panel: Operate as specified under (2) and (3).

Stopping a motor.

24–41. To stop a motor, it is only necessary to open the line switch or trip the circuit breakers, or in the case of the drum controller to throw the controller arm to the off position. See that moving elements on the panel have all returned to the off, or starting, position.

Procedure in case of failure to start.

24–42. If the procedure outlined in article 24–40 fails to start the motor, proceed as follows:

(a) Using a voltmeter, or an electrician's test lamp, check the presence of voltage at the line switch.

(b) Examine fuses and replace any that may have blown.

(c) Check over the panel connections for a loose or broken connection, and feel for evidence of burning or local heating.

(d) Check connections in the motor leads at panel and motor headboard.

(e) Search out the motor trouble.

Switch and lever operation.

24–43. Care should be taken when operating switches or rheostat arms to watch the contact points. Heavy sparking, indicating poor or broken contact, should be investigated and remedied at once. In opening field switches, the blades should be drawn out slowly, allowing the field to discharge with a drawn-out spark. This will prevent the establishment of a high potential in the field coils which might break down a weak point in the insulation.

Heat as a trouble indicator.

24–44. The operating personnel should be constantly on the alert for the presence of unusual or unexplained heat around the control panel. Heat is the primary index of electrical trouble. If excessive heat is noted about the panel, one of two conditions is usually indicated. Either the line leads to or from the panel are too small in current-carrying capacity, or a loose or insufficient contact exists at some connection point. In any panel made by a reputable manufacturer, and subjected to naval inspection, the chance of insufficient carrying capacity in any of the electrical leads or devices on the panel proper is very improbable. Incoming or outgoing cables, however, occasionally are undersized. A loose contact, especially where cable attachments are made, generates heat in considerable quantity and will lead to inevitable casualty unless the condition is remedied. Such trouble can usually be traced by finding the position of greatest local heat.

Overload blowout.

24–45. If, on starting up a motor equipped with a drum type controller, the fuse or circuit breaker goes out due to an overload, be sure and move the controller arm to the off position before renewing the fuse or resetting the circuit breaker.

Starting resistance left in.

24–46. With a motor controlled by an automatic contactor panel, the operator should determine, after starting the motor, that all the starting resistance has been cut out before he leaves the panel. If all the accelerating contactors do not close, the condition will probably be best indicated by the failure of the motor to build up to its normal speed. Failure of one of these contactors to close will leave some of the starting resistance in the armature circuit, and this, if left in, will soon overheat and burn out.

Use of wiring diagrams.

24–47. Large motors, such as those used for anchor gear, steering gear, capstans, and boat cranes, are usually operated by a master distant controller. It is necessary that personnel handling equipment of this character be thoroughly familiar with the wiring diagrams of the control circuits, which are usually of a rather complicated character. These diagrams generally contain a table giving the contactors which should be closed for various positions of the master controller, and intelligent use of this table will make it possible to trace trouble readily.

Distribution of personnel.

24–48. Due to the complicated nature of the wiring diagrams, it often happens that the major part of work of repair is accomplished when the trouble is found, as the fault is usually trifling and easily remedied. A frequent example is the failure of a contactor to close because of dirt or dust on an interlock through which its control circuit passes. A great trouble saver with equipment involving this dual control is a ship order requiring the presence of a competent electrician in the panel room whenever the distant controller is being used. An electrician thoroughly familiar with the contactor panel and the power sources can almost always keep equipment in operation through moments of crisis when his absence would mean a shutdown.

Panel doors.

24–49. When panels are not in use and they are supplied with doors, keep the doors closed.

PART 2.—CARE AND REPAIR.

Panels—General care.

24–60. Controllers of the panel type should be frequently wiped off by using a brush known as a "painter's duster," having no metallic binding, and made of soft bristles about 4 inches long. If it is necessary to clean off anything other than dust, use a soft flannel rag or a piece of chamois skin. The use of cotton waste or rags which will leave lint shall be avoided. Frequent examination shall be made to insure that all connections are tight. Connections should be soldered or brazed if practicable. Panels are often placed so that the back of the board is inaccessible for ready examination. In such case, the heat test may be relied upon to indicate trouble, but as soon as heat is discovered, the panel should be pulled down at once to find and remedy the trouble. The condition of the wires behind the board should be investigated frequently if possible. The tendency of the ship's structure to weave will sometimes cause enough movement of the wires behind the board to result in their abrasion with consequent breakdown. If it becomes necessary to remove moisture from a panel, use a flannel cloth, and subject the panel to a baking process if the damage is serious. Remember that surface moisture is a conductor, and its presence on a panel will often account for low circuit insulation resistance readings.

Panels—Care of devices.

24–61. Adopt a routine inspection for overload and no load release mechanisms. Keep the spring on the starting rheostat arm strong enough to throw the lever to the off position in the event of voltage failure. Keep contact buttons tight, clean, and of uniform height. If they become badly burned, replace them. See that sliding contacts are smooth, and bear evenly on the contact buttons. The use of oil around electrical panels and equipment is usually dangerous because inexperienced personnel become careless and oil creepage and dirt accumulation result. The overload and no voltage release armature hinge pins, the starting lever shaft, and solenoid contact blocks, should occasionally be dismounted and cleaned with fine sandpaper. If this apparatus is kept bright and free from dirt and paint, there is little opportunity of its sticking. The use of oil on electrical panel devices will eventually result in breakdown of insulation resistance.

Switches.

24–62. Switch clips should be kept smooth and tight to insure good contact when the switches are closed. Switches are designed carefully to give a much lower value of amperes per unit of cross-section than that of the amperes per unit cross section of the entering or leaving cables, but this value at the switch contact rapidly rises if the clips become loose or the contact area becomes roughened due to burning, dirt, or verdigris. The effect will be an increase in temperature.

Circuit breakers and contactors.

24–63. Examine circuit breakers and contactors frequently to see that contacts are in proper condition and that all connections are tight. Should the contacts be burned, smooth them down with a file or renew them as occasion demands. Laminated brushes should be lubricated with a light film of vaseline, and hinge pins with a few drops of medium oil. No lubrication should be used on the copper or carbon arc-rupturing contacts. See that the levers work freely and that there is no tendency to stick, which

will prevent the opening of the breaker. Check circuit breakers periodically to make sure that they blow at the limiting current for which they are set. If not properly set, calibrate them, and enter the results in the electrical log.

Rheostats.

24–64. Rheostats are more liable to short circuits than any other of the panel accessories and should receive special attention. They shall be kept dry and as free from dust and dirt as possible. Wipe off the exposed molded insulation surfaces frequently to keep down surface leakage, and if these surfaces break or crack renew them. If the rheostat gets wet, it shall be carefully wiped and dried before being put in service again. If convenient, it should be dried in a warm room, but if not practicable, then it may be slowly warmed by allowing a low current to pass through it until all moisture has been expelled. Start with about one-fourth of the rated current, and, as the rheostat warms up, gradually increase the current until, if no trouble develops, full current is allowed to flow. This condition should continue until the insulation resistance readings are normal, approximately 1 megohm or better. To remove dust and dirt, use the "painter's duster;" and to reach the inaccessible parts, use a bellows or a blast of dry air.

Drum controllers, general care of.

24–65. Care shall be taken in examining controllers of the drum type to see that cover gaskets are not broken or damaged, and that they seat all around with a good contact. With weather deck controllers, special care shall be exercised to keep stuffing boxes and water caps well packed. Covers removed for inspection should be replaced at once. Keep polished steel surfaces slushed with grease to prevent rust and corrosion, and lubricate the shaft bearings with a small amount of heavy oil. Trouble will occasionally develop from grounding of the blow-out or arc-rupturing coils placed at the base of the controller. Due to their location these coils are often subjected to excessive moisture and dampness, and their inaccessibility causes them to be neglected. For this reason particular effort should be given to keeping the base of the controller housing tight and free of moisture.

Drum controllers, care of devices.

24–66. Controllers shall be examined frequently enough to insure smoothness and even bearing of the fingers and contacts. Any roughness shall be smoothed up with a file as soon as discovered, and if the condition is bad the part shall be renewed. Fingers shall be kept in such adjustment that, as the segments pass under them, they will lift about one-sixteenth of an inch. Always examine the fingers of deck controllers after heavy gunfire. Unless they happen to be of a special design, they will tend to loosen and drop by gravity off their normal contact. Lubricate bearing surfaces with a light film of vaseline. The star wheels mounted on the controller shaft, whose function is to determine the various positions of controller movement, are often neglected. Wheel and pawl should be kept free of dirt and verdigris and kept coated with a light coat of grease or vaseline. Keep inflammable materials away from arc deflectors.

Automatic controllers, general care.

24–67. The very fact that a panel is automatic in its action is prone to cause its neglect, while a little thought will show that by its nature it should be subjected to frequent periodic rigid inspections. Wiring diagrams should be kept always available, and are

usually complicated enough to justify a special study. Thorough familiarity with the sequence of operation will often save valuable time at moments of critical breakdown.

Automatic controllers, care of devices.

24–68. Keep the main and auxiliary contactor contact surfaces clean and bearing uniformly. Keep the auxiliary contact impact springs at an even tension, and renew those that are defective. Give the protective devices, overload, and no-voltage devices, a frequent periodic inspection and test. On these tests note the proper operation and sequence of the contactors, for the need for minor repair and adjustment to one contactor will often disable the panel. Keep the flexible connector terminals tight and watch for other chances of open circuit in the control circuits. See that the flame deflectors are properly placed to prevent a spreading arc, and keep inflammable material away from them. Keep the panel clean and dry, and lubricate sparingly, especially at the hinge pins of contactors, levers, and armature, taking care to wipe off all excess oil.

Panel surfaces.

24–69. Surface moisture must be kept at a minimum on panels of all descriptions, to hold up the circuit insulation resistance readings. The use of alcohol for cleaning panels is dangerous and shall not be allowed. Not only is an inflammable substance being used but the alcohol will break down the finished surfaces of panels and of the instruments thereon. The general practice of lacquering panels not only improves appearance, but is done specially to fill the panel grain, producing a polished surface which does not absorb and hold moisture. If it becomes necessary to renew a panel surface, requisition should be placed on the navy yard for some type of panel lacquer on the current Navy acceptable list.

Fuses.

24–70. Fuses can be a considerable source of trouble if they are not used and replaced intelligently. They should always have a carrying capacity about one-third in excess of the normal load current they are designed to protect, and should never be installed haphazard. When renewable fuses are used, the fusible element shall be installed in the shop where good light and facilities are available, to insure tight and adequate contacts. Unless an immediate emergency exists, the blowing of a fuse should always be investigated to determine the cause which produced the overload. Using fuses of higher capacity or increasing circuit-breaker setting without investigating the trouble on the defective circuit can not be too strongly disapproved.

Section III.—Periodic Tests and Inspections.

Part 1.—Generating Sets.

Daily.

24–80. Daily.

(1) Examine each running generating set as to the condition of the commutator, the lubricating system, the governor action, bearing temperature, vibration, etc.

(2) Each generating set not in use shall be turned over daily, and the fact entered in the log.

Weekly.

24–81. Weekly.

Each generating set shall be run at least 30 minutes weekly to insure that nothing has developed to impair its efficiency, and the fact entered in the log. If it is not practicable to carry out this requirement due to navy-yard work, extensive overhaul, or casualty, a log entry shall be made stating the facts.

NOTE.—During the course of this test, generating sets shall, when fitted with a spring valve to the atmospheric exhaust, be run noncondensing for a sufficient time to insure that this valve is in first-class condition and capable of operating automatically against the back pressure for which the spring is set. On turbo-generating sets, test the emergency governors and see that they trip at about 10 per cent above the normal speed. Test other protective devices associated with the sets for positive action, including the shunt trip on the generator circuit breakers and back pressure trips if fitted.

Quarterly. 24–82. Quarterly.

Make insulation tests on all spare armatures. Examine the commutators and rotate the armatures through three-quarters of a turn to accomplish a visual examination for general condition, and to counteract the effect of sagging due to its weight.

Annually. 24–83. Annually.

(1) Shut all power off the main generator boards and the distribution boards, and give them a thorough examination for chafing, for loose nuts and connections, and blow out dust and dirt with a dry air blast. Enter in the log.

(2) Take the name-plate data for all generators for inclusion in N. Eng. 260, "Annual Report of Electric Plant Data."

PART 2.—MOTORS.

Daily. 24–90. Daily.

(1) Examine each running motor thoroughly at least once daily, noting specially the condition of the commutator, oil cups and rings, bearing temperatures, etc.

(2) If time is available, test each motor circuit for grounds daily. In making the test, place the controller arm on the first starting position, so as to include the motor and all resistance. If a ground detector voltmeter is installed, the presence of a ground can be determined at the switchboard. Individual circuits can then be pulled out until the ground disappears. This method will isolate the troublesome circuit and regular use of the detector will tend to keep the entire wiring free from grounds.

Weekly. 24–91. Weekly.

Operate each idle motor once each week for at least 10 minutes, noting its operation and insuring that nothing has developed which will interfere with its efficiency. Enter the accomplishment of these tests in the log.

Quarterly. 24–92. Quarterly.

(1) Check the speed of each motor against its name-plate data.

(2) Make a special motor circuit insulation test for entry on pages 3 and 4 of N. Eng. 33, "Quarterly Report of Electric Plant."

(3) Make insulation tests on all spare armatures. Examine the commutators, and rotate the armatures through three-quarters of a turn to accomplish a visual examination for general condition and to counteract the effect of sagging due to its weight.

Annually. 24–93. Annually.

Take the name-plate data on all motors for inclusion in N. Eng. 260, "Annual Report of Electric Plant Data."

PART 3.—CONTROLLERS AND CONTROL PANELS.

24–95. Daily. Daily.

(1) Test each control appliance actually in use through its cycle of operation to insure that it is functioning satisfactorily.

24–96. Weekly. Weekly.

(1) Note the satisfactory operation and condition of control appliances in conjunction with the test of motors specified under paragraph 24–91. On this test pay special attention to the heat conditions on and around the control panel.

24–97. Quarterly. Quarterly.

(1) Investigate the conditions behind those panels which are placed in such position that their backs are ordinarily inaccessible. If the panel is clean, shows no local heat, the insulation resistance is of good value, and the operation satisfactory, the panel should not be dismounted. If these conditions are not fulfilled, it should be pulled down, to correct any defects and to clean it.

24–98. Annually. Annually.

(1) Take data on all controllers for inclusion in N. Eng. 260, "Annual Report of Electric Plant Data."

Section IV.—Safety Precautions.

24–100. (a) Electrical machinery shall not be started after an overhaul until after an inspection has been made for loose bolts, improper clearance, short circuits, broken insulation, tools adrift, etc. The speed of the machine after starting, likewise ammeter readings of field and armature, should be checked with the instruction book and recorded.

(b) After a machine has been started, if running temperatures are excessive, the trouble shall be traced and rectified before extensive running is undertaken.

(c) Machines shall not be run in excess of their designed rated load except in emergency, and the upper limit of 25 per cent overload shall never be exceeded.

(d) The designed r. p. m. of machines shall not be exceeded.

(e) If brushes are shifted in a machine that is running, great care must be taken against raising the yoke out of its support, thus pulling the lower brush holders into the commutator and causing serious damage.

(f) Examine and rectify at once conditions causing sparking, as these conditions, if not rectified, will rapidly become aggravated.

(g) Keep the interior and exterior of machines free from water, salt, lint, dust, and particularly oil.

(h) Gasoline or other inflammable liquids shall not be used about electrical machinery, where a spark may cause ignition.

(i) Emery shall not be used on electrical machinery. Sandpaper shall be used instead.

(j) If the emergency governors fail to trip at approximately 10 per cent in excess of the normal speed, the machine shall not be run until the governors have been regulated.

(k) All protective devices for electrical machinery, panels, circuits, etc., such as fuses, circuit breakers, no-voltage and overload releases, etc., shall be kept in proper working order and at their designed settings at all times.

(l) Covers for all screw-type fuse boxes, junction boxes, etc., shall be kept on and screwed down tight; lever-type boxes shall habitually be kept closed; gaskets on all boxes shall be kept in good condition and free from paint.

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